NEVADA DEPARTMENT OF TRANSPORTATION
RESEARCH PROBLEM STATEMENT

Internal Submission Form (not to exceed 3 pages with font size 11)

I. PROBLEM TITLE: The Optimal Shoulder for Reducing Speed Related and Lane Departure Crashes.

II. PROBLEM DESCRIPTION: Speed-related and lane departure crashes are significant contributors to road crashes, leading to injuries, fatalities, and substantial economic costs. Therefore, understanding how shoulder slope impacts road safety is of paramount importance. This study is prompted by the presence of fatal rollover crashes occurring in newly constructed and flattened road conditions in US-95 MM10 to MM69 Nye County.

III. OBJECTIVE: The primary objective of this study is to comprehensively evaluate and determine the most suitable shoulder slope configuration for mitigating speed-related and lane departure crashes on highways. To achieve this overarching goal, the research aims to:

- **Define Optimal Slope Geometry:** Identify the ideal shoulder slope angle and design that enhances vehicle stability, facilitates driver recovery during lane departure crashes, and minimizes the severity of speed-related crashes.
- **Analyze Driver Response to Slope:** Investigate how the choice of shoulder slope influences driver behavior during lane departure scenarios, with a focus on whether specific slope types increase the likelihood of drivers regaining control.
- **Assess Safety Performance:** Evaluate the comparative safety performance of various shoulder slope designs by quantifying their effectiveness in reducing both the frequency and severity of speed-related and lane departure crashes.
- **Conduct Economic Evaluation:** Examine the construction and maintenance costs associated with different shoulder slope configurations and determine their cost-effectiveness in relation to potential savings resulting from reduced crash rates.
- **Consider Environmental Impact:** Assess the environmental implications of diverse shoulder slope designs, encompassing considerations related to land use, drainage, and ecological factors.
- **Provide Policy Recommendations:** Derive evidence-based policy recommendations and guidelines from the research findings to inform highway design standards and advocate for the adoption of safer shoulder slope configurations by relevant transportation authorities and policymakers.
- **Final Report:** Compile research results into a final report.

IV. CURRENT PRACTICE and RELATED RESEARCH:

Road Design Guide (NDOT), 2019:

- Roadside slopes are the inclines of areas beside the road shoulder, positioned between the shoulder and the right-of-way boundary. To enhance safety, it is preferable to design relatively flat areas adjacent to the road to reduce the risk of accidents like vehicle turnovers, vaulting, or collisions with drainage channels. The Department establishes appropriate side slope limits for roads based on their intended function and use, as detailed in Table 3.12.

Table 3.12

Height (Feet)	Cut Slopes*		Fill Slopes
	Fore Slope	Back Slope	
0 to 5	10:1	10:1	10:1
5 to 10	6:1	6:1	6:1
10 to 15	4:1 or flatter	4:1	4:1
Over 15	4:1 or flatter	2:1**	2:1**

*Refer to Roadside Design Guide 2011, Figure 3-6 for preferred channel cross sections

**Slopes steeper than 2:1 require a Geotechnical evaluation

- Foreslopes, which run parallel to traffic flow, can be categorized as recoverable, non-recoverable, or critical.
- Recoverable foreslopes are those with a gradient of 4:1 or flatter, and if they are smooth and traversable, clear-zone distances can be determined from "Table 3-1. Suggested Clear-Zone Distances in Meters (Feet) from Edge of Through Traveled Lane" in the 2011 Roadside Design Guide, Page 3-3.
- Non-recoverable foreslopes are traversable but difficult for most vehicles to stop or return to the roadway from. These typically have slopes between 3:1 and 4:1.
- Critical foreslopes are those where errant vehicles are more likely to overturn, and they usually have slopes steeper than 3:1. More details on these foreslopes can be found in Section 3.2.1 of the 2011 Roadside Design Guide, Pages 3-4 and 3-5.

A Policy on Geometric Design of Highways and Street, 7th edition, 2018:

- Well-designed and adequately maintained shoulders are essential for rural highways with significant traffic, freeways, and high-speed urban highways.

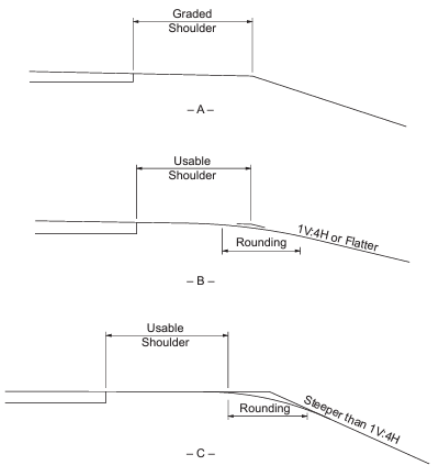

Figure 4-4. Graded and Usable Shoulders

V. IMPLEMENTATION POTENTIAL:

Maintenance Protocols: To utilize the study's findings effectively, NDOT should establish and adhere to regular inspection and maintenance protocols for road shoulders. These protocols

should focus on mitigating erosion, minimizing debris accumulation, and ensuring the stability of shoulders. By proactively addressing these issues, NDOT can enhance road safety and reduce the risk of fatal rollover crashes.

Leveraging Shoulder Slope Assessment: By evaluating the geometry, gradient, and overall condition of shoulder slopes, NDOT can pinpoint areas requiring improvement to create a safer roadside environment.

Applying Engineering Solutions: NDOT can apply engineering solutions informed by the study's results to address shoulder slope concerns effectively. These solutions may entail modifying the shoulder slope angle, enhancing road design, or improving the overall road geometry. The objective is to create a roadside environment that is more forgiving to drivers, reducing the likelihood of rollover crashes.

VI. URGENCY and PAYOFF POTENTIAL: The urgency of conducting this research in the current fiscal year is underscored by the alarming toll on human lives. In the span of just 7 months, from January 2023 to July 2023, our region has witnessed a staggering 12 fatal crashes. These tragic incidents represent a profound loss of life, and they serve as a compelling call to action for immediate research and intervention.

The frequency of these fatal crashes highlights an urgent need for solutions.

In conclusion, the urgency of addressing this issue is indisputable, driven by the unfortunate toll of 14 fatal crashes in a short timeframe. Conducting this research in the current fiscal year is not only a moral imperative but also a practical necessity to safeguard lives, reduce economic burdens, and instill a sense of security in our community.

VII. DATE and SUBMITTED BY: September 28, 2023

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FIVE STAGES OF RESEARCH DEPLOYMENT

Based on Caltrans Research and Innovation Stages

1. **Concept Stage**
   - First steps following Problem Statement and Proposal Development
   - Includes detailed literature search
   - Involves experimental design, data collection, analysis, and reporting
   - Assesses results of research
   - Defines barriers to implementation (e.g., policies, specifications, standards)
   - Submits a Final Report and outlines a recommended implementation plan
   - Includes collaboration with outside agencies or other state DOTs and US DOT (Applies to all Stages of Deployment)
2. **Laboratory Prototype Stage**
   - Develops breadboard circuit or computer system modeling
   - Demonstrates operation in laboratory setting
   - May incorporate customized or one-of-a kind components
   - Assesses results
   - Submits Final Report and recommends design of full-scale demonstration
   - Potential end users are enlisted to support the field pilot stage
3. **Controlled Field Demonstration Stage**
   - Prepares for full scale testing of demonstration project
   - Controlled tests at specialized facilities are observed and supported by cooperating agencies, industry, and technical associations
   - Potential end users are enlisted to support the field pilot stage
   - Assesses results
   - Submits Final Report and recommends site/conditions for first application pilot stage
4. **First Application (Contract) Field Pilot Stage**
   - Works with potential end users to select site and to conduct pilot testing under real world operating conditions
   - Test specifications and standards are developed
   - Research assistance given to assure proper installation and operation
   - Problems are corrected and adjustments made, as necessary, to complete pilot testing
   - To the extent possible, potential end users operate the project under careful research surveillance
   - Assesses results
   - Submits Final Report and recommends initial sites for full corporate deployment
   - Potential end users are enlisted to support the field pilot stage
5. **Specification & Standards with Full Corporate Deployment Stage**
   - End users select site(s) and deploy the method/process/equipment using resident management, supervision, staff, and contracting forces (where applicable)
   - Deployment is without research supervision or direction
   - On call assistance is available upon request
   - Assesses results